

Allocation of CO₂ emission permits—Economic incentives for emission reductions in developing countries

Tobias A. Persson*, Christian Azar, Kristian Lindgren

Department of Physical Resource Theory, Chalmers University of Technology and Göteborg University, SE-412 96 Göteborg, Sweden

Available online 11 March 2005

Abstract

The economic impacts on developing regions following a global cap and trade system for carbon dioxide are assessed through the use of an energy-economy systems model. Both an equal per capita allocation and a contraction and convergence allocation with convergence of the per capita emissions by 2050 are shown to offer economic incentive for Africa, India and probably also Latin America to accept binding emissions commitments under a 450 ppm carbon dioxide stabilization scenario. The gain for Latin America is mainly a result of increased export revenues from sales of bio-fuels as a result of the climate policy. It is, on the other hand, unlikely that these allocation approaches would offer an economic incentive for China to join the regime because of its high economic growth, present higher per capita emissions than India and Africa, and more costly mitigation options than Latin America. A more stringent allocation for developing countries such as contraction with convergence of the per capita emissions by the end of this century is estimated to generate reduced net gains or increased net losses for the developing regions (though Africa is still expected to gain).

© 2005 Elsevier Ltd. All rights reserved.

Keywords: Emissions trading; Future commitments; Abatement cost

1. Introduction

One of the more difficult and complex issues in the international negotiations on climate change is how to get developing countries to abate their emissions. Several approaches have been discussed, e.g., voluntary agreements, non-binding targets, intensity targets, or some kind of targets but only for the most advanced developing countries (see SEPA (Swedish Environmental Protection Agency), 2004). In this paper, the implication of an approach that is built on the current Kyoto architecture is analysed, i.e., binding absolute targets with full freedom to trade in emission permits. The chosen allocation approach must be acceptable for most countries, both developed and developing. It must deal with issues such as: equity, environmental effectiveness, economic certainty and economic efficiency.

So far, international negotiations on the control of greenhouse gases (GHGs) emissions have not reached consensus on the issue of commitment types or processes beyond the first Kyoto commitment period. Several commitment types and allocation principles, however, have been suggested and analysed in the literature (see, e.g., Beckerman and Pasek, 1995; Harvey, 1995; Gupta and Bhandari, 1999; Azar, 2000; Baer et al., 2000; Meyer, 2000; Neumayer, 2000; Philibert, 2000; Torvanger and Ringius, 2000; Berk and Elzen den, 2001; Winkler et al., 2002; Aldy et al., 2003; Gheri et al., 2003).

Developing country representatives have argued that, the industrialized countries bear the primary responsibility for the climate problem and should therefore bear the brunt of emission reductions. This is recognized in Article 3.1 of the United Nations Framework Convention on Climate Change (UNFCCC) in Rio de Janeiro in 1992, which states that the developed and developing countries have ‘common but different responsibilities’ (Article 3.1, UNFCCC).

*Corresponding author. Tel.: +46 31 7723455; fax: +46 31 7723150.
E-mail address: frtt@fy.chalmers.se (T.A. Persson).

VISIT...

LANZAROTE
Caliente.COM

However, the US senate adopted a resolution (S.RES. 98) in July 1997 with 95 votes in favour and zero against, stating that the US would not accept any binding reduction targets under the UN framework convention on climate change, in the absence of meaningful developing country participation. The unilateral focus on industrialized countries was also one of the prime reasons that George W. Bush invoked when stating that the US would withdraw from the Kyoto Protocol.

In this paper, it is assumed that the climate change regime shall have high environmental certainty in emission levels, i.e., the commitments are hence binding and absolute. However, stringent absolute binding commitments are probably not acceptable for developing countries in the near term due to the expected effects on their economic development; binding emission commitments for developing countries are by some also seen as unfair. The permits allocated to developing countries must, hence, be generous enough so as to provide financial incentives to join. In this paper, the following allocation approaches are evaluated:

- Equal per capita 2020—all people have an equal right to pollute from the first commitment year, emission permits are thus proportional to population. This approach results in a generous allocation of permits to developing countries.
- Contraction and convergence 2050—permits are allocated on the basis of convergence of per capita emissions in 2050 under a contracting global emission profile.
- Contraction and convergence 2100—permits are allocated on the basis of convergence of per capita emissions in 2100 under a contracting global emission profile. This approach results in a rather stringent allocation of permits to developing countries compared to the two other approaches.

The reason for choosing these three regimes is that they result in significantly different amount of permits allocated to the developing regions and they therefore could be used as an indication of whether any reasonable allocation approach could be used as an economic incentive for developing countries to accept emission reduction commitments. Other approaches such as multi-stage, the Jacoby rule and the revealed-preference method result in permits allocated to developing countries amounting to levels between the equal per capita 2020 and the contraction and convergence 2100 approaches (SEPA, 2004). A 2020 per capita approach would lead to a lot of opposition by the countries in the North (and some countries in the South). Contraction and convergence 2100 would require continuous reductions in the North (opposition could still be expected, but less so than in the equal per capita 2020 case), but this would be much more stringent for countries in the

South (and face resistance also in that part of the world). Contraction and convergence by the year 2050 is a middle case. Judging the political feasibility of these regimes would probably require a paper of its own. The aim in this paper is to estimate the economic impact on developing regions, except OPEC which is analysed in a separate article (Persson, 2005), from each of these approaches.

Some studies have suggested that even a generous allocation to developing countries may result in negative economic impacts on some developing regions such as China and Latin America with presently high per capita emissions in comparison to other developing regions (Elzen den et al., 2005; WBGU (German Advisory Council on Global Change), 2003). We analyse by using a regionalized energy-economy model, how robust their conclusions are for a 450 ppm CO₂ stabilization (which is roughly equivalent to a 550 CO₂-equivalent stabilization with other GHGs included) by testing the three regimes mentioned above for the period 2000–2050. Our model explicitly estimates how carbon abatement policies affect trade in fossil fuels and biomass. This enables us to analyse how regions, such as Latin America, that may sell both emission permits and bio-energy may be affected by international climate policies.

The paper is structured as follows. The method and model are presented in Section 2. In Section 3, the trade in carbon permits for the different allocation approaches is presented. In the same section, the social costs or benefits for the developing regions is estimated. The section also includes a sensitivity analysis. Some conclusions are given in Section 4.

2. Methodology

2.1. Energy-economy model

GET-R 2.0 is a global energy-economy model which is a modified version of the GET-R 1.0 model (see Grahn, 2002; Azar et al., 2003 for details). The transport sector has been simplified but the energy demand is price elastic (the demand is proportional to $p^{-\varepsilon}$ where p is price and ε is the price elasticity). The model is a partial equilibrium model with perfect foresight composed of three different parts: the primary energy supply, the final energy demand, and the energy conversion system. The energy demand is endogenous for three end-use sectors—transportation fuel, electricity and direct fuel use. All technologies have their own characteristics in terms of investment costs (the estimation of costs are intended to reflect the situation once the technologies are mature), lifetime, efficiency, and load factor. The time-step in the model is 10 years and the model runs until 2130. The objective function of the model is the sum of consumer

and producer surplus. In this way, the model chooses to lower energy use when the price of energy increases.

The model has 11 regions: North America (NAM), Western Europe (WEU), Pacific Annex I, Former Soviet Union, Central and Eastern Europe, Africa (AFR), non-Annex I Pacific Asia (PAS), Latin America (LAM), Centrally Planned Asia including China (CPA), and South Asia including India (SAS). Future levels of population growth and GDP are assumed to follow the A1 scenario developed by IIASA/WEC which has the same regions as the GET-R 2.0 model (Nakićenović et al., 1998). This population scenario assumes high growth numbers but lower growth rates have been used in the sensitivity analysis.

In GET-R 2.0, CO₂ emissions can be reduced by (i) higher efficiency (energy demand is price elastic), by (ii) carbon capture and storage and (iii) fuel switching, i.e., the CO₂ emissions is reduced by expanding the production of non-carbon emitting energy sources such as wind, biomass and hydro, or shifting from fuels with high carbon-to-energy ratios (such as coal) to fossil fuels with lower carbon-to-energy ratios (such as natural gas). These technologies will increase the energy costs, which results in a reduced energy demand compared to the reference scenario. A price elasticity of 0.35 for industrialized regions and 0.45 for developing regions¹ has been assumed in the base case but different values have been used in the sensitivity analysis. The aggregated CO₂ emissions in the 450 ppm scenarios are allowed to be 680 GtonC during this century (IPCC (Intergovernmental Panel on Climate Change), 1995).

2.2. Allocation of emission permits

In this paper, two types of allocation approaches for a climate regime based on absolute emission commitments (emission caps) are evaluated for developed and developing regions: (i) equal per capita 2020 and (ii) contraction and convergence. The international climate regime is assumed to begin in the year 2020, before that the CO₂ emissions in Annex B² countries, except the US, follow the commitments in the Kyoto Protocol while the other countries', including the US, emissions follow the reference scenario without any carbon policy.

For the contraction and convergence approach, two different convergence years are compared, 2050 and 2100 (Fig. 1), respectively. The permits are assumed to

¹The price elasticity in this model is assumed to be higher in developing countries mainly due to two reasons: (i) their energy systems grow and price changes would influence the investments into more energy-efficient technologies; (ii) there is a larger potential for efficiency improvement in developing countries than in most industrialized countries. Note that these price elasticity numbers do not include the effects of taxes or other social costs except for a CO₂ price.

²Annex B is the group of countries which have absolute emission commitments in the Kyoto Protocol.

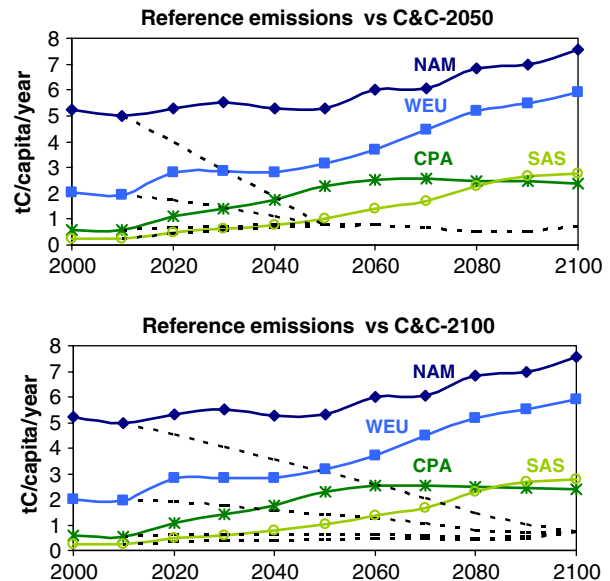


Fig. 1. Carbon emissions on a per capita basis from the combustion of fossil fuels. The dashed line is an example of contraction and convergence (C&C) allocation with convergence of the per capita emissions in years 2050 and 2100, respectively, under the assumption that the atmospheric CO₂ concentration is stabilized at 450 ppm. This allocation is compared to the emissions in the reference scenario from GET-R 2.0 for four regions NAM (North America), Western Europe (WEU), Centrally Planned Asia (CPA) and South Asia (SAS).

follow linear trends from the per capita level by 2010 towards an equal per capita allocation by the convergence year. The allocated emission permits are then assumed to follow the equal per capita emission profile towards the stabilization target. However, linear trends do not exactly generate the allowed emission profile leading to the CO₂ stabilization target of 450 ppm. The permits that correspond to the difference between the linear trends and real emission profile are equally distributed to the regions on a per capita basis. This creates only small differences from the linear trends as can be seen in Fig. 1. Only carbon dioxide from the energy and transport systems is considered in this analysis. We have thus excluded carbon sources and sinks from land use changes and non-CO₂ GHGs. The reason for that are the uncertainties when it comes to estimating costs and when it comes to the method that should be used to include these emission sources (see, e.g., Azar and Persson, 2005). For some regions the inclusion could change the results significantly, e.g., Brazil with large emissions from deforestation. For studies that have included non-CO₂ GHGs, see Vuuren van et al. (2003).

3. Results

In this section, the results from the analysis of the equal per capita and contraction and convergence

allocation approaches are presented. The atmospheric concentration of CO₂ is assumed to be stabilized at 450 ppm. A perfect emission trading system is assumed. It is thus assumed that the suppliers of permits are sufficiently numerous so that no single permit seller can affect the price received by withholding permits from the market or demand a price over the optimum where the demand and supply for permits equilibrate. Without emissions trading, it can be expected that the structural development of energy systems and costs will be significantly different than shown in this paper. The results only show numbers for the developing regions since that is the focus of this paper.

In the presentation of the results, some numbers are compared to expected GDP values calculated into USD using Market Exchange Rates. The total abatement costs are also compared to GDP using Purchasing Power Parity exchange rate as the impression of the results can be different. The ratio of MER-based and PPP-based GDP can be larger than a factor of two during the first decades but converges over time as income levels rise in developing countries.

3.1. Emissions trading and financial flows

During the first decades of the trading regime, all developing regions except the PAS are sellers of emission permits when they are allocated on an equal per capita basis (Fig. 2). Two regions, SAS and AFR with presently low per capita emissions are the major sellers. Both these regions have a surplus of permits, “tropical hot air”, which are not generated by any regional mitigation efforts. On average until the middle of this century the annual amount of hot air in both these regions combined is over 1000 MtonC per year which is roughly equal to the present emissions in WEU. The OECD region is the buyer of these emission permits. By 2030 and onwards also CPA is a buyer of emission permits.

In a contraction and convergence regime (Fig. 2), the amount of hot air in developing regions is reduced. The reason is that such an allocation is more stringent for the developing regions during the coming decades than an equal per capita allocation is. For example, the number of emission permits South Asia receives in an Equal per Capita allocation with the long-term stabilization target of 450 ppm is almost 1700 MtC in 2020 which could be compared to 760 and 590 MtC in the contraction and convergence 2050 and contraction and convergence 2100 allocation schemes, respectively. South Asia is a buyer of emission permits during the analysed period when the convergence is by the end of this century. Africa on the other hand continues to have tropical hot air during the first decades both in a contraction and convergence 2050 and contraction and convergence 2100 allocation regime.

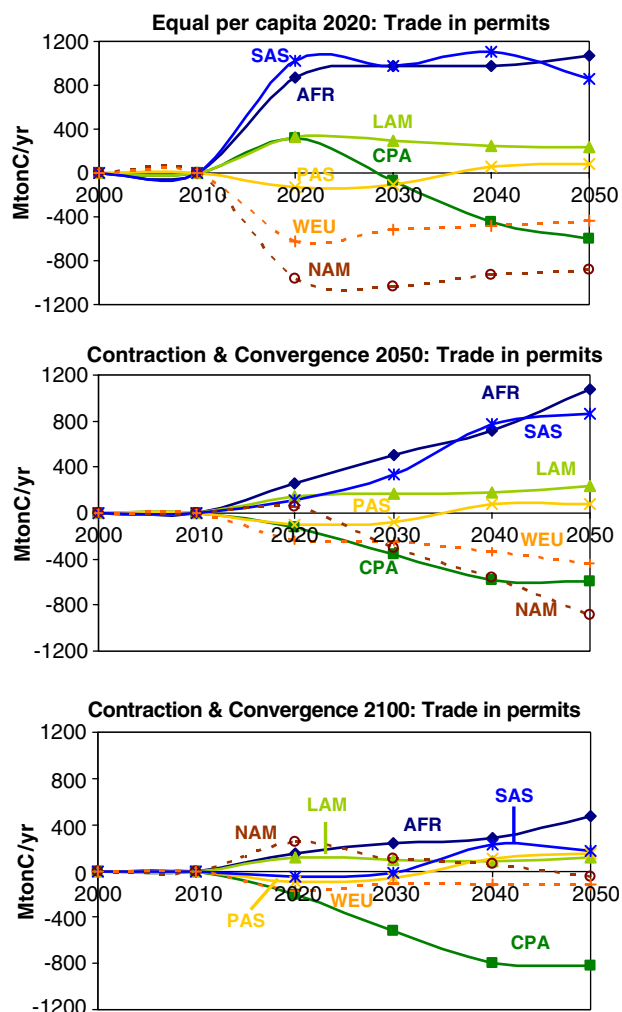


Fig. 2. Trade in permits in an equal per capita allocation regime, and two Contraction and Convergence allocation regimes with convergence by 2050 and 2100, respectively, stabilizing the concentration of CO₂ in the atmosphere at 450 ppm. Positive values correspond to export of permits while negative correspond to import of permits. Trade numbers for AFR (Africa), SAS (South Asia), LAM (Latin America), CPA (Centrally Planned Asia), PAS (non Annex I Pacific Asia), WEU (Western Europe) and NAM (North America) are shown.

The trading of emission permits generates a financial flow from the demanding to the supplying regions. The financial flows are equal to the traded volumes multiplied by the permit price. How much the developing regions will gain or lose from trading of permits is thus dependent on the development of the permit price. The carbon permit price is assumed to grow by 3 per cent per year from roughly 50 US\$ per tonC by year 2020 to over 130 US\$ per tonC by 2050 in the base case scenario.

In present value terms, emissions trading generates during the first half of this century a transfer from industrialized countries to developing countries amounting to approximately 1190 billion US\$ with an equal per capita allocation and 460 billion US\$ with a contraction and convergence 2050 allocation. On the other hand, an

allocation based on contraction and convergence 2100 generates a transfer of money from developing countries (as a group) amounting to roughly 50 billion US\$.

The revenue to the major exporting regions during the first decades with a more generous allocation than contraction and convergence 2100 approach, Africa and South Asia, amounts annually from 15 to 70 billion US\$ for each region. The higher number is for an equal per capita allocation while the lower is for a contraction and convergence 2050 allocation. This can be compared to the Official Development Assistance (ODA) in the year 2003 which amounted globally to roughly 58 billion US\$. The annual financial flow increases towards the middle of the century as the permit price increases and a large amount of permits continues to be traded. The major permit exporting region by the middle of this century, Africa, has an annual revenue of over 150 billion US\$ when the allocation is based on equal per capita or contraction and convergence 2050. If the allocation of permits is based on a contraction and convergence 2100 approach the annual profit revenue from permit sales in Africa during this year is reduced by 50 per cent compared to the contraction and convergence 2050 approach.

3.2. Social costs

In addition to the trade in emission permits reported above, this section presents social costs that include domestic mitigation costs and the cost/gain of trading permits. Lower CO₂ emissions will entail costs since more expensive energy technologies are required and less energy is used (measured as a reduction of the consumers' and producers' surpluses). CO₂ restrictions can also have considerable impacts on trade flows of fuels. A reduced demand for carbon intensive fuels can be expected while the demand for renewable energy sources such as bio-fuels can increase.

The global net present value of aggregated abatement costs for the whole century, not taking into account any benefits from stabilizing the CO₂ concentration, is estimated to be over 3000 billion US\$ for reaching 450 ppm (the numbers are discounted to 2000 with a discount rate of 5 per cent per year). This number is comparable to those presented in the latest IPCC assessment (chapter 8 in IPCC (Intergovernmental Panel on Climate Change), 2001). Total abatement costs in relation to expected GDP are indicated to peak in 2080 but remain well below 1.5 per cent during the whole century.

However, the regional values including revenues or costs from emissions trading and the mitigation costs as percentage of expected GDP—the “effort rate”—can be higher or lower than 1.5 per cent (Figs. 3 and 4). Africa and Latin America actually have a net gain in the three allocation regimes during the first half of this century.

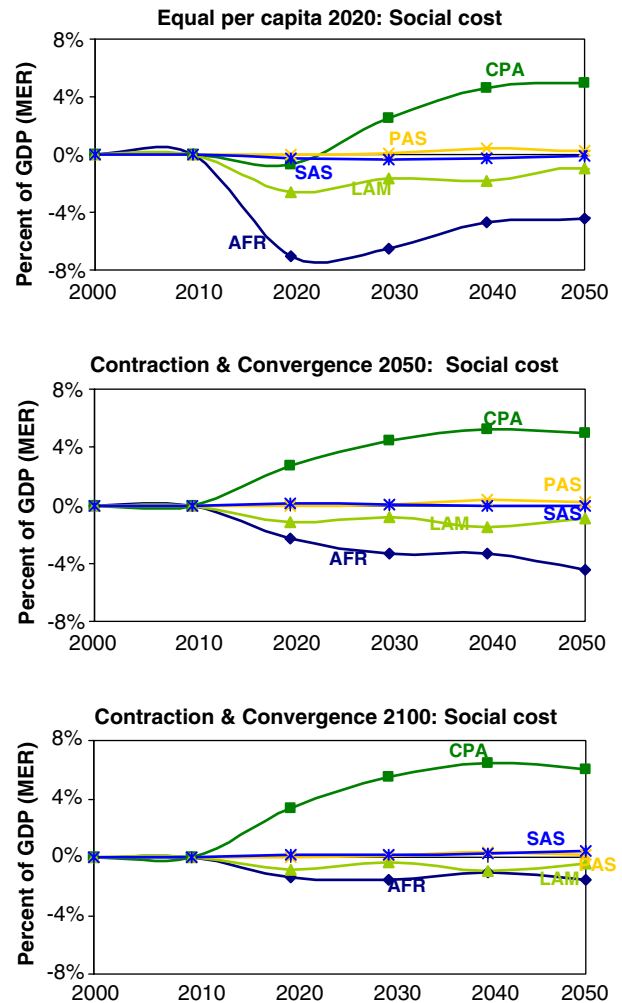


Fig. 3. Net social costs (including costs or revenues from emissions trading) as percentage of expected GDP_{MER} in an equal per capita regime, and two Contraction and Convergence allocation regimes with convergence by 2050 and 2100, respectively, stabilizing the atmospheric CO₂ concentration at 450 ppm. Five developing regions AFR (Africa), SAS (South Asia), LAM (Latin America), CPA (Centrally Planned Asia) and PAS (non Annex I Pacific Asia) are shown.

Africa has the highest present value gain with an equal per capita allocation, almost 540 billion US\$ which can be compared with 150 billion US\$ with a Contraction and convergence 2100 approach. South Asia has also a high substantial net gain when the allocation is based on an equal per capita approach, over 330 billion US\$ in net present value. However, the net revenues are reduced to less than 30 billion US\$ with a contraction and convergence 2050 approach and there is actually a net present value cost of over 200 billion US\$ if the convergence is by the end of the century.

For both Africa and South Asia, the amount of permits allocated, hence, significantly affect the size of the gain and a restrictive allocation could result in costs for South Asia. The present value gain is not that dependent on allocation approach in Latin America.

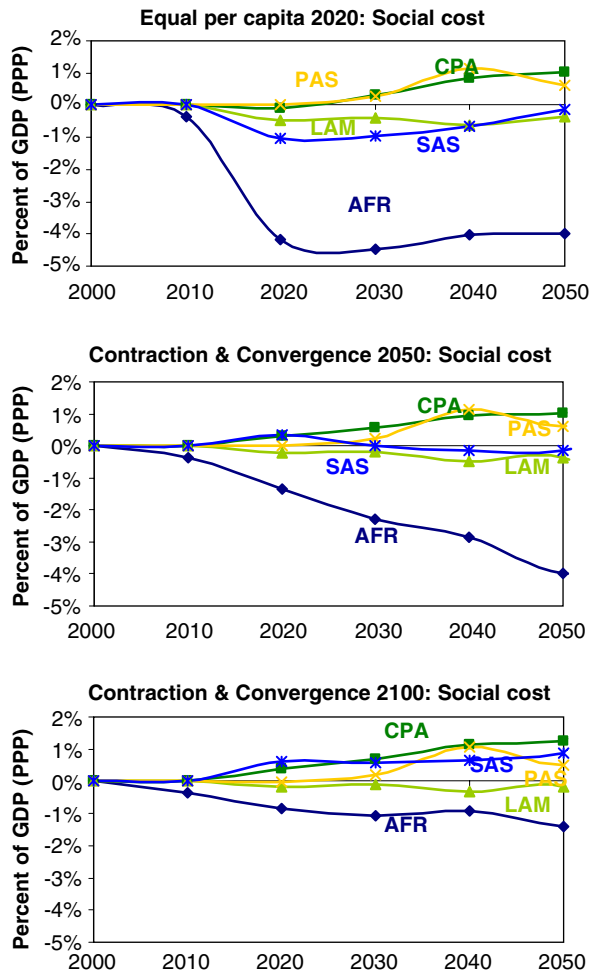


Fig. 4. Net social costs (including costs or revenues from emissions trading) as percentage of expected GDP_{PPP} in an equal per capita regime, and two Contraction and Convergence allocation regimes with convergence by 2050 and 2100, respectively, stabilizing the atmospheric CO₂ concentration at 450 ppm. Five developing regions AFR (Africa), SAS (South Asia), LAM (Latin America), CPA (Centrally Planned Asia) and PAS (non Annex I Pacific Asia) are shown.

The gain in this region is more a result of benefits of export of bio-fuels. The gain is rather stable around 100 billion US\$.

CPA including China has a net present value cost ranging from 280 to 510 billion US\$ for the equal per capita and contraction and convergence 2100 allocation approaches, respectively. Almost half of this cost consists of purchasing of emission permits from other regions. The annual abatement cost as percentage of GDP peaks at over 5 per cent of the expected GDP_{MER} by the end of the analysed period or 1 per cent of expected GDP_{PPP} for a contraction and convergence 2100 allocation. On average, the annual cost as percentage of GDP_{MER} is 4.7 per cent of the expected GDP_{MER} in a contraction and convergence 2100 regime (0.8 per cent in PPP terms), 4.2 per cent with a 2050 convergence year (0.7 per cent in PPP terms) and 2.9 per

cent (0.5 per cent in PPP terms) with an equal per capita allocation. The analysed allocation approaches also result in costs for the non-Annex I Pacific region. However, the cost is smaller than for CPA, especially relative to expected GDP. The abatement cost as percentage of expected GDP_{MER} is 0.1 per cent on average between 2020 and 2050 for all three analysed allocation approaches.

The major explanation for the costs with the allocation approaches in CPA and PAS is the present high per capita emissions in comparison with other developing regions, the emission target by 2050 which is almost the same as the present per capita emissions in these regions and the expected rapid economic development. The emissions in the reference scenario surpass the assigned amount of permits already in 2020 and the regions are then confronted with substantial amount of emission reduction requirements in the abatement scenario. The base case results from the model thus indicate that a contraction and convergence 2050 allocation of emission permits to China will not provide an economic incentive for China to accept binding absolute commitments. Similar results for China have been obtained by Elzen den et al. (2005) and WBGU (2003). These studies also report a net cost for Latin America while our results indicate a net gain. The robustness of these results is analysed in the next section.

3.3. Sensitivity analysis

The base case scenario, i.e., the scenario that leads to atmospheric stabilization at 450 ppm, indicates that Africa, Latin America and South Asia may gain from a CO₂ mitigation regime with the schemes for allocation of emission permits analysed in this paper while PAS and CPA are expected to experience net costs. Because of the large amount of uncertainty that surrounds all long-term scenarios studies, a sensitivity analysis has been performed to examine the robustness of the results. The following alternative situations have been tested: a low population scenario, higher fuel availability (both fossil fuels and biomass), higher bio-fuel production costs in developing countries, restriction on the use of carbon capture and storage, and higher/lower price elasticity. Fig. 5 summarizes the sensitivity analysis for the three different allocation approaches.

3.3.1. Population growth

A lower population growth scenario has been investigated (numbers from IMAGE (Integrated Model to Assess the Global Environment), 2001). In this scenario, the population development is almost as low as in the UN low population scenario (UN (United Nations), 2002). By 2050, the global population is 8.7 billion which can be compared to 10.0 billion in the base

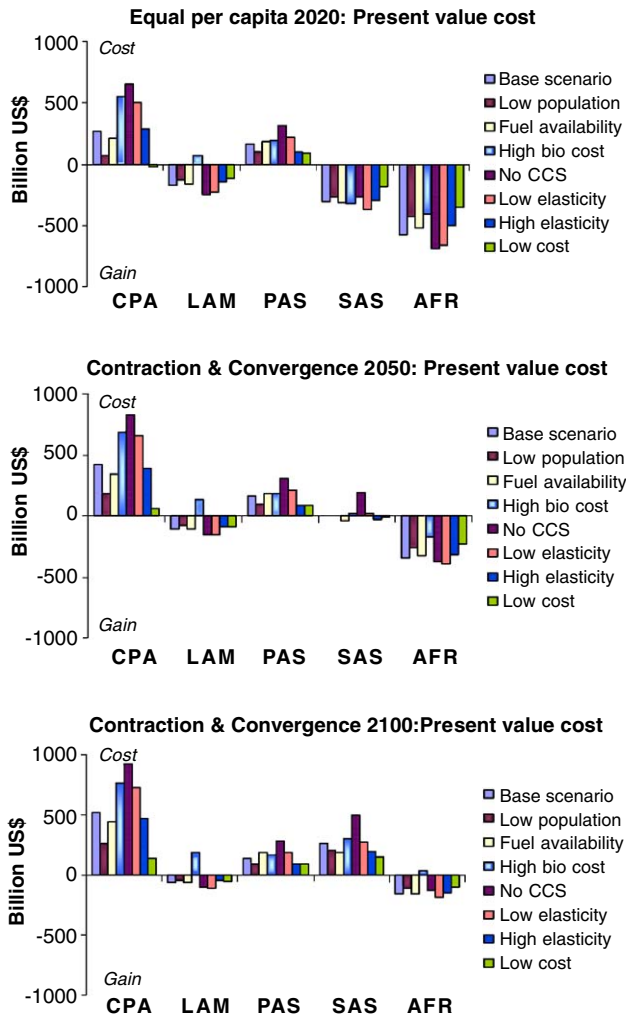


Fig. 5. Net present value costs (positive values) and gains (negative values) given in billion US\$ for the period 2020–2050, for different scenarios and an equal per capita allocation, and two Contraction and Convergence allocation regimes with convergence by 2050 and 2100, respectively.

case analysis. The regional energy demands and GDP levels are reduced in this scenario as the development of these variables are proportional to the population development. The emission reduction requirements for a 450 ppm stabilization is hence reduced compared to the base case, and thus also the abatement costs. A lower population scenario changes also the allocation of emission permits, fast growing countries like India and most African countries will be allocated a smaller share of the permits.

Although the world net present value abatement costs for this century in this scenario is one-third lower than in the base case, it is interesting to note that the basic features of the results in the base case remain. One potentially important observation is, however, that a low population growth scenario implies that the net present value cost for CPA is reduced by 50–70 per cent depending on the allocation approach. The net cost with

an equal per capital allocation is actually very small. For PAS the relative reduction in net present value cost is also high, about 40 per cent for all three allocation approaches. The reduction in present value costs for both regions is mainly a result of reduced mitigation costs but also a consequence of the fact that the cost of purchasing permits decreases. Africa with a fast growing population reduces on the other hand the gain by 20–25 per cent which mainly is a result of reduced income from selling of emission permits. For India, which also has a fast growing population in the base case scenario, the impact is much smaller since the reduction of mitigation cost is more important than in Africa.

3.3.2. Availability of fuels and technological options

The sensitivity with respect to changes in parameters determining resource availability and technological options was also tested.

The analysis shows that a 30 per cent higher resource base for fossil fuels, which have a cumulative restriction in the model (see [Grahn, 2002](#), for more details), and for bio-fuels, which have an annual restriction in the model, results also in reduced world net present value abatement cost but the impact is smaller than for a lower population scenario; the cost is reduced by 20 per cent. A further consequence of the higher resource base is reduced export profits to Latin America from sales of bio-fuels as the demand decreases, but still the region has a net gain about 15–20 per cent lower than in the base case scenario for all allocation approaches.

A higher bio-fuel production cost would reduce profits from biomass sales in Latin America and would thus lead to overall higher costs for the climate regime. For example, a 50 per cent higher bio-fuel production cost in developing countries results in a scenario where Latin America has a net cost for all allocation approaches. Further, a higher bio-fuel production cost also increases the costs for the importing regions, e.g., net present value costs increases by 50–100 per cent compared to the base case scenario in CPA depending on the allocation approach. The world net present value abatement cost for this century also increases significantly, by over 30 per cent.

If carbon capture and storage is not allowed in the model, the global net present cost for this century increases by 45 per cent compared to the base case scenario. Especially coal-dependent regions, such as CPA, PAS and South Asia are in this scenario confronted with extra costs since carbon capture and storage from fossil fuels is one of the most important mitigation options for these regions. By not allowing carbon capture and storage the more costly solar energy options will play a more important role in both the medium and the long-term. For CPA the net present value cost increases in relation to the base case scenario by 75 per cent for a contraction and convergence 2100

allocation and could more than double with an equal per capita allocation. In absolute terms, the extra cost for CPA is about the same in all three cases, around 400 billion US\$ in net present value for the period 2010–2050. Another result is that only an equal per capita allocation offers gains for South Asia during the first half of this century.

3.3.3. Price elasticity

How costs depend on the price elasticity of the final energy demand is also tested. In the base case the price elasticity is 0.45 in developing countries, for the low elasticity case it is assumed to be 0.3 and for the high elasticity scenario, a value of 0.7 is assumed. A high price elasticity means that the cost to meet a given constraint decreases. For example, the world net present value abatement cost for this century is reduced by more than 20 per cent compared to the base case scenario when the price elasticity is 0.7 while an elasticity of 0.3 results in 25 per cent higher cost. However, it is interesting to note that all main results in this paper hold but the elasticity assumption can have an influence on cost or gains especially on those in which the CO₂ mitigation cost or sales of fuels are very important for the total abatement cost. For a region such as PAS higher price elasticity results in a reduction of the abatement cost by around 40 per cent for all three allocation approaches.

A low price elasticity implies that a higher carbon price is needed to obtain the same CO₂ target. This means higher fuel prices. The gain in Latin America increases therefore by around 50 per cent while fuel importing regions such as CPA and PAS face 30–60 per cent higher costs.

3.3.4. Low cost combination

A combination of low population, high resource base and high price elasticity assumptions were also tested. As shown above all these assumptions result in lower world net present value abatement costs and in combination the reduction is even more significant, almost two thirds below the base case scenario abatement cost. One important implication is that an equal per capita allocation can offer a small gain for CPA and a contraction and convergence 2050 approach only results in a small cost.

4. Conclusions and discussions

To stabilize the concentration of GHGs in the atmosphere at low levels requires that both the industrialized and developing countries abate their emissions. Economic analyses show that the economic cost of stabilizing the atmospheric concentration of CO₂ will be lower if developing countries adopt abatement

commitments under the UNFCCC already from the beginning. In this paper, it is analysed whether incentives for developing countries to join would be provided if emissions permits to developing countries were allocated based on the following approaches: equal per capita, and contraction and convergence with convergence years 2050 and 2100, respectively. Whether these allocation approaches could offer an economic incentive for developing regions to accept absolute commitments have been evaluated for a 450 ppm stabilization of the atmospheric CO₂ concentration. The developing countries are assumed to have commitments from 2020 and onwards.

An allocation based on equal per capita or contraction and convergence has some advantages, e.g., simplicity, transparency, environmental certainty (i.e., certainty in global emission each commitment period) and compatibility with the Kyoto Protocol. But there are also disadvantages, e.g., the risk for “tropical hot air” and that these approaches do not consider structural differences of countries as stated in the UNFCCC. (For more on the pros and cons on various allocations methods, see Elzen den, 2002; Höhne et al., 2003; SEPA, 2004; Torvanger et al., 2004). However, the aim of this paper is not to suggest or promote any specific allocation approach. The regimes assessed in this analysis are chosen since the amount of permits allocated to each region differs significantly and other allocation approaches are hence expected to fall within the ranges of the three approaches studied here.

Before discussing the specific results, it is important to keep in mind the large uncertainties that are involved in modeling the global energy system some 50–100 years ahead. It is clearly close to impossible to foresee technological options and costs for such long time periods, and globally aggregated models will by necessity be poor in capturing region-specific features (such as options for energy efficiency, etc). For that reason, some degree of skepticism against the results presented in this (as well as in many other) model is justified. On the other hand, one reason for doing such modeling work is that countries will need to assess the implications of various proposals for cap-and-trade systems to deal with the problem of climate change, and then aggregated global models such as the one presented in this paper will be part of the arsenal to address these questions.

An equal per capita allocation would generate a huge flow of money from industrialized to developing countries, especially to Africa but also to South Asia during the first decades. Both these regions have presently low per capita emissions and an equal per capita allocation creates “hot air” in both regions, i.e., emission allowances that do not result from real abatement activities. An equal per capita allocation

would offer an incentive for both these regions to join a regime based on absolute commitments.

An equal per capita allocation could also offer economic incentives for Latin America to accept absolute commitments. This incentive, however, is mainly an effect of increased export of bio-fuel. For CPA including China it is unlikely that even a generous allocation such as equal per capita could offer an economic incentive to accept absolute commitments.

Whether a contraction and convergence approach may work out as an economic incentive for developing countries to accept absolute commitments depends on the convergence year. South Asia is estimated to gain from a convergence of the per capita emissions in 2050 while convergence by the end of this century is estimated to result in net costs. A late convergence year could actually result in imports of emission permits from other developing and industrialized countries to South Asia and also CPA. The reason for this is that a late convergence date implies that the emission allowance trajectory towards that date becomes lower for poor countries and higher for rich countries. A contraction approach with convergence by 2050 and by 2100 are both expected to result in a net gain for Africa (with the annual gain actually exceeding the present ODA to the region). Other studies, similar to ours, e.g., [Elzen den et al. \(2005\)](#) and [WBGU \(2003\)](#) have reported a substantial net cost for Latin America. However, the results here show a net impact on Latin America that fluctuates around zero. The exact number depends on the availability and price of bio-energy. The region is actually estimated to receive a significant net gain due to export of bio-energy (since the potential for bio-energy is expected to be large).

The results thus show that most developing regions with low per capita emissions could gain by accepting absolute commitments. However, there is a risk that developing regions with relatively high per capita emissions (around 0.6 tC/cap/year or higher) and an expected rapid economic growth could have a net present value cost. The annual regional cost could peak at five per cent for some regions (when compared to GDP levels converted into US\$ using market-based exchange rates, while the use of purchasing power based GDP result in a lower impact). On the other hand, this cost is small in comparison to the expected economic growth rate for these regions. For example, by 2050 CPA GDP is expected to grow by 3 per cent annually and have a cost of almost 6 per cent of the expected GDP. Thus, the achievement of a much higher income level than today would only be delayed by 2 years (see [Azar and Schneider, 2002](#), for a more detailed discussion on this).

Finally, the question about how to get developing countries onboard is clearly much more complicated than simply handing out emission permits in a generous

manner. There are at least four key factors for more effective negotiations between industrialized and developing countries:

- Given the position of many OECD countries in negotiations about tariffs on agricultural products, it is fair to expect developing countries to be sceptical about promises about large gains from joining any cap and trade system for carbon. This is particularly true since most developing countries do not have models or modellers of their own, or institutional capacity to assess the results of complex models developed in the North.
- Even if short-term benefits were expected to be rather certain (e.g., as would be the case with a very generous baseline), developing country concerns about the long-term implications of accepting climate targets would still be valid. They see that the industrialized world developed with fossil fuels and that it has still not been able to reduce their emissions (except for a few countries with special circumstances). For that reason, one cannot expect developing countries to take on real mitigation commitments before the developed countries have actually demonstrated that it is possible to reduce the emissions and at the same time maintain a high standard of living (as recognized in Article 3 of UNFCCC). A successful mitigation post 2012 regime under the UNFCCC is thus especially dependent on the reengagement of the US.
- Currently, carbon emission reductions are not an issue in many developing countries. For that reason, if the North wants to see more action in developing countries, there needs to be support to an agenda building process in these countries. This process could include support to research exchange, support to environmental organizations, etc. It is also important to find actions that could have multiple benefits, e.g., support to the diffusion of more efficient stoves, improvement of public transportation (such as Curitiba Mass Transit System), the build up of institutions that encourage energy efficiency, i.e., activities that if effectively implemented could generate support for climate policies. It must also be recognized that many developing countries do not have sufficient institutional capacity to deal with all the complex issues dealt with during the negotiations (see, e.g., [Müller, 2003](#)). For that reason, there needs to be increased support to build up such capacity.
- Finally, while the South has so far been reluctant to talk about mitigation targets (see e.g., India's Prime Minister Vajpayee's high-level segment opening address at COP8 where he stated three reasons why it is unfair for developing countries to enhance their mitigation commitments under the climate convention today), the North has been reluctant to talk

about the concerns of many developing countries, which currently are more tilted towards getting compensation for current and expected climate damages.³

A key conclusion from these observations is that a generous allocation scheme is unlikely to be sufficient to convince developing countries to take on stringent targets. Instead, these “political boundary conditions” for the negotiations need to be considered. However, some more advanced developing countries already have relatively high per capita emissions and incomes and tend to view themselves as industrialized, e.g., South Korea, Argentina, Mexico, Cyprus, Brazil, Saudi Arabia, Iran and Turkey. These developing countries have probably the institutional capacity to take on targets and it could be argued that they should do so when the industrialized countries have shown progress. This might open up for more developing countries to join as their income and emission levels grow.

Acknowledgements

Maria Grahn is gratefully acknowledged for her development and regionalization of the GET model. Financial support from the Swedish Energy Agency is gratefully acknowledged. Dean Abrahamson is acknowledged for comments on early manuscripts.

References

- Aldy, J.E., Barrett, S., Stavins, R.N., 2003. Thirteen plus one: a comparison of global climate policy architectures. *Climate Policy* 3, 373–397.
- Azar, C., 2000. Economics and distribution in the greenhouse. *Climatic Change* 47, 233–238.
- Azar, C., Persson, U.M., 2005. Fighting future fires with fairness. *Nature* 433, 13.
- Azar, C., Schneider, S.H., 2002. Are the economic costs of stabilizing the atmosphere prohibitive? *Ecological Economics* 42, 73–80.
- Azar, C., Lindgren, K., Andersson, B.A., 2003. Global energy scenarios meeting stringent CO₂ constraints—cost-effective fuel choices in the transportation sector. *Energy Policy* 31, 961–976.
- Baer, P., Harte, J., Haya, B., Herzog, A.V., Holdren, J., Hultman, N.E., Kammen, D.M., Norgaard, R.B., Raymond, L., 2000. Equality and greenhouse gas responsibility. *Science* 289, 2287.
- Beckerman, W., Pasek, J., 1995. The equitable international allocation of tradable carbon emission permits. *Global Environmental Change* 5, 405–413.
- Berk, M.M., Elzen den, M., 2001. Options for differentiation of future commitments in climate policy: how to realise timely participation to meet stringent climate goals? *Climate Policy* 1, 465–480.
- Elzen den, M., 2002. Exploring post-Kyoto climate regimes for differentiation of commitments to stabilize greenhouse gas concentrations. RIVM report 728001020/2002. National Institute of Public Health and the Environment, Bilthoven, the Netherlands.
- Elzen den, M., Lucas, P., Vuuren van, D., 2005. Abatement costs of post-Kyoto regimes. *Energy Policy* 33, 2138–2151.
- Gherzi, F., Hourcade, J.-C., Criqui, P., 2003. Viable responses to the equity-responsibility dilemma: a consequentialist view. *Climate Policy* 3, S115–S133.
- Grahn, M., 2002. Global energy scenarios meeting stringent climate targets—a comparison between the global energy system model GET 1.0 and the regionalised model GET-R 1.0. Master Thesis, Department of Physical Resource Theory, Chalmers University of Gothenburg and Göteborg University, Sweden.
- Gupta, S., Bhandari, P.M., 1999. An effective allocation criterion for CO₂ emissions. *Energy Policy* 27, 727–736.
- Harvey, L.D.D., 1995. Creating a global warming implementation regime. *Global Environmental Change* 5, 415–432.
- Höhne, N., Galleguillos, C., Blok, K., Harnisch, J., Phylipsen, G.J.M., 2003. Evolution of commitments under the UNFCCC: involving newly industrialized economies and developing countries. Research Report 201 41 25, UBA-FB 00412. Federal Environmental Agency, Berlin, Germany.
- IMAGE (Integrated Model to Assess the Global Environment), 2001. The IMAGE 2.2 implementation of the SRES scenarios: a comprehensive analysis of emissions, climate change and impacts in the 21st century. RIVM CD-ROM publication 481508018, National Institute for Public Health and the Environment, Bilthoven, The Netherlands.
- IPCC (Intergovernmental Panel on Climate Change), 1995. *Climate Change 1994: Radiative Forcing of Climate Change and an Evaluation of the IPCC IS92 Emission Scenarios*. Cambridge University Press, Cambridge UK.
- IPCC (Intergovernmental Panel on Climate Change), 2001. *Climate Change 2001—Mitigation, Contribution of Working Group III to the Third Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, UK.
- Meyer, A., 2000. *Contraction and Convergence: The Global Solution to Climate Change*. Schumacher Briefing No. 5, Greenbooks for the Schumacher Society, Bristol, USA.
- Müller, B., 2003. *Framing Future Commitments—A Pilot Study on the Evolution of the UNFCCC Greenhouse Gas Mitigation Regime*. Oxford Institute for Energy Studies, Oxford, UK.
- Nakićenović, N., Grübler, A., McDonald, A., 1998. *Global Energy Perspectives*. Cambridge University Press, Cambridge, UK.
- Neumayer, E., 2000. In defence of historical accountability for greenhouse gas emissions. *Ecological Economics* 33, 185–192.
- Persson, T.A., 2005. Will an International Climate Policy Result in Decreasing OPEC Oil Export Revenue? Work in Progress. Chalmers University of Technology, Göteborg, Sweden.
- Philibert, C., 2000. How could emissions trading benefit developing countries. *Energy Policy* 28, 947–956.
- SEPA (Swedish Environmental Protection Agency), 2004. *Climate Cooperation Beyond 2012—Report on a Government Assignment on Future International Climate Cooperation*. Stockholm, Sweden Available at: <http://www.naturvardsverket.se>.
- Torvanger, A., Ringius, L., 2000. Burden differentiation: criteria for evaluation and development of burden sharing rules. The joint CICERO-ECN Project on Sharing of Burden of Greenhouse Gas Reduction Among Countries. Working paper 2000:1. CICERO, Oslo, Norway.

³One of the main reasons for the North to be reluctant is that climate change under the climate convention is defined as “a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time period”. To define climate effects is hence presently difficult as natural effects should not be compensated for under the convention.

- Torvanger, A., Twene, M., Vevatn, J., 2004. Climate policy beyond 2012: a survey of long-term targets and future frameworks. Report 2004:02. CICERO, Oslo, Norway.
- UN (United Nations), 2002. World population prospects: the 2002 revision. Available on <http://esa.un.org/unpp>.
- Vuuren van, D.P., Elzen den, M.G.J., Berk, M.M., Lucas, P., Eickhout, B., Eerens, H., Oostenrijk, R., 2003. Regional Costs and Benefits of Alternative Post-Kyoto Climate Regimes. RIVM Report no. 728001025. National Institute of Public Health and the Environment, Bilthoven, The Netherlands.
- WBGU (German Advisory Council on Global Change), 2003. Climate protection strategies for the 21st century: Kyoto and beyond. Berlin, Germany.
- Winkler, H., Spalding-Fecher, R., Tyani, L., 2002. Comparing developing countries under potential carbon allocation schemes. *Climate Policy* 2, 303–318.